CURRENT STATUS OF VEGETATION MANAGEMENT IN ROADSIDE DITCHES AND STORMWATER MANAGEMENT FACILITIES

by

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EXECUTIVE SUMMARY

This research report is an initial assessment of current vegetation maintenance practices in bioswales, wetponds, and roadside ditches. Through the use of interview surveys and a literature review, this report has compiled empirical evidence to evaluate the effects of different maintenance practices, particularly mowing, on the pollutant-removal capabilities of these facilities. Of particular focus is the continuing need for improved maintenance practices and a recognition of several important unmet research needs in this area.

The results of the survey documented a significant lack of information on the types of mowing practices or vegetation that provide the greatest improvement to the quality of the water leaving these facilities. The current best management practices (BMP's) for vegetation maintenance and mowing, specified in agency-developed design manuals, have been established through general observation and are based on the assumption that greater grass densities remove more pollutants. However, some of the limited published research conflicts with these assumptions for certain pollutants of concern.

Current vegetation management practices are being implemented by local governments in the Puget Sound lowlands to the maximum extent that jurisdictional budgets will allow. Yet these practices are frequently not in accord with design standards. The primary shortfall is in the lack of removal of grass clippings after mowing. The water-quality consequences of this failing are completely unknown.

Future research in several areas could significantly improve current vegetation management programs, particularly in (1) how to maximize stormwater treatment throughout the storage and conveyance system, and (2) how to minimize agency maintenance costs by identifying unnecessary or ineffective actions. Optimizing the pollutant removal capabilities of bioswales, wetponds, and roadside ditches is essential to make efficient use of the existing drainage system for water-quality improvement. Such optimization is also likely to achieve a significant improvement in overall watershed conditions. Data to guide agencies in these areas, however, are simply not available at the present time.

INTRODUCTION

The primary objective of this study was to determine what information exists on the role of vegetation maintenance in roadside ditches, wetponds, and bioswales as a means of improving the water quality of urban and suburban runoff. The specific focus was to determine how the management of the vegetation will affect the water-quality and pollutant removal performance of these stormwater facilities. A second objective was to determine the degree to which scientific findings, if any, have been incorporated into routine maintenance practices for local jurisdictions in the Puget Sound lowlands. These two major parts of this study were accomplished through an extensive literature search and personal interviews. The interviews covered eight nationally recognized individuals in stormwater management, together with a large number of local and regional public-agency managers charged with vegetation management. A third and final objective of this study was to recommend avenues of research that can lead to improved practices in this area.

METHODS

Literature Search

A literature search was conducted using the following databases: Water Resources Abstracts (1967-April 1997), GeoBase (1980-present), GeoRef (1986-present), National Technical Information Service (1983-present), Aquatic Sciences and Fisheries Abstracts (1978-present), Environmental Science and Pollution Management Database, and the Cambridge Scientific Abstracts Database. Searches were conducted for key words, including *vegetation maintenance*, *biofiltration swale*, *biofiltration*, *wetpond*, *roadside ditch*, *nutrient removal*, *phosphorus removal*, *vegetation management*, and *detention pond*. In addition, published surface-water design manuals from the Washington State Department of Ecology and King County were referenced to determine current BMP's for mowing and any other vegetation management practices in wetponds, bioswales, and roadside ditches.

Interviews

Two groups of people were interviewed for this study. First, nationally recognized stormwater management professionals were contacted to confirm the preliminary findings of the literature search and to act as a resource for information on projects being undertaken in the area of vegetation management for stormwater facilities. Second, a group of interviews were conducted with individuals from local agencies around Puget Sound who are charged with the maintenance of wetponds, bioswales and roadside ditches. It became apparent early in the investigation that the major concern and expense in vegetation maintenance in these facilities involved mowing of grass. As a result, this project focused most specifically on mowing.

Based on the development of this emphasis, information was gathered on the nature and range of typical practices for mowing, including:

- Frequency,
- Types of equipment used,

- Miles of ditches mowed,
- Number of sites maintained, and
- Costs of maintenance per mile and per stormwater facility.

RESULTS

Literature Search

The results of the literature search were disappointing but revealing—very little specific research has been conducted on vegetation maintenance for stormwater facilities. A significant amount of research has been undertaken on the *design* of bioswales and wetponds, but none of the reviewed studies have attempted to establish the effects of various types of vegetation maintenance or mowing practices on the efficiency or effectiveness of the facilities.

The few references to vegetation and its desirable properties for different types of pollutant removal are contradictory. For example, in a study focused on sediment removal Van Dijk et al. (1995) refer to a 1967 paper by L.G. Wilson. This paper stated that suitable filter grass species should "(a) have a deep root system, (b) have a high stalk density, (c) be insensitive to submergence and droughts, and (d) be able to grow through sediment coverage." In contrast, a study conducted in Florida in 1984 came to the conclusion that bare earthen (*i.e.* unvegetated) swales were more effective than grassed swales in the removal of heavy metals due to the higher surface area available for adsorption (Harper et al., 1985; Yousef et al., 1985). Yet they also concluded that the removal of nitrogen, phosphorus, and heavy metals is "directly related to infiltration" and that retention of water in the swale is the key to reducing contaminant transport to receiving waters (Yousef et al., 1985). They suggested that the optimal strategy for increasing contact and residence times consisted of establishing a cover vegetation for erosion control, keeping the vegetation viable through removal of clippings, and planting a slow-growing species with low maintenance needs if possible (Yousef et al., 1985).

A few investigations have also been conducted locally. An evaluation of the condition of already-constructed ponds and swales was conducted in one region of relatively recent new development by John Koon of King County Surface Water Management (King County,1995). It determined that, of the facilities surveyed, only 35% of the wetponds and 28% of the swales were in full working order. The failures were attributed to a combination of poor design, construction problems, and inadequate maintenance.

A biofiltration swale study (King County,1992), conducted by King County and the cities of Seattle and Mountlake Terrace, recognized the likely importance of maintenance in facility performance. The study offered several judgments about the optimal characteristics and maintenance needs for vegetation in bioswales, based on general observation. It suggested that regular mowing is important for several reasons:

- it encourages higher density grass,
- it keeps the grass from getting too long where it can become too heavy and lay over which tends to channelize flow and in turn reduces residence time and adsorption capability,
- it maintains the grass at the height for which the swale was designed,
- it provides for removal of vegetative litter (such as leaves) that can hinder grass vitality,

- it prevents clogging of outflow structures through litter and clipping removal, and
- it can prevent the return of the nutrients to the receiving water system that have been taken up by the plants if the clippings are removed.

These judgments formed the basis of guidelines in the most recent draft version of the King County Surface Water Design Manual (King County,1996) for the maintenance of publicly owned and maintained stormwater facilities. The Design Manual states:

> "Grass should be mowed to maintain an average grass height between 4 inches and 9 inches, depending on the site situation. Monthly mowing is needed from May through September to maintain grass vigor. If the swale is not mowed at least annually, trees and brush will invade the swale and inhibit grass growth, compromising the swale's performance for water quality treatment."

> "Grass clippings should be removed from the swale and composted on site or removed from the site and disposed of properly."

No specific reference was found in the draft King County Design Manual regarding vegetation maintenance of public roadside ditches.

The standards for maintenance of private facilities presented in the draft King County Design Manual (King County, 1996) are explicitly intended to maintain conveyance or aesthetic objectives, not treatment objectives. They state that the maintenance of privately managed open ditches should be undertaken when vegetation "reduces free movement of water through ditches" (p. A-9), but the Design Manual does not address specifically what that action should be. In wetponds and bioswales, the grass or groundcover should be mowed when it exceeds 10 inches in height "such that flow is not impeded" (p. A-10). In wetponds, the vegetation "need to be mowed when it starts to impede aesthetics of pond" (p. A-11).

The Stormwater Management Manual for the Puget Sound Basin, compiled by the Washington Department of Ecology (1992), states that biofiltration swales must be "mowed regularly during the summer to promote growth and pollutant uptake" (p. III-6-7), must not be mowed to a height below the depth of the design flow, and should have cuttings removed from the site. For the maintenance of ponds, this manual uses the same guidelines as the King County Design Manual (King County,1996). For guiding the maintenance of roadside ditches it states that practices should be undertaken "in a manner that insures that the vegetation will be reestablished by the next wet season thereby minimizing erosion of the ditch as well as making the ditch effective as a biofilter." No specific guidance to achieve these objectives, however, is offered.

Interviews

Several dozen stormwater professionals were contacted in late 1997 and early 1998 (a list of the contacts is presented in Table 1). None of these people had additional knowledge of any current research being performed on the subject of how mowing practices in bioswales, wetponds, and roadside ditches affect water quality. The most closely related effort is being undertaken by Pierce County, which is currently performing a study to establish the most cost-effective method of vegetation management in roadside ditches (John Schnaderbeck, personal communication). This study does not analyze the effects of the different management activities on water quality, however.

Results of the survey of current practices of local and regional agency managers are presented in Table 2. The entries within the various categories are not fully comparable, due to different methods of management in terms of budgeting and units used to measure ditch length maintained, but they do indicate trends in current management practices:

- Most agencies mow bioswales, wetponds, and roadside ditches two to three times per year, primarily during the growing season;
- Counties are the most instrumental in these activities, because their jurisdictions encompass the unincorporated areas which include the major portions of the land base and road infrastructure that includes open ditches;
- Cities do not have as many ditches or facilities and tend toward piping of stormwater runoff to receiving waters;
- In some cases, no maintenance is being performed at all or it is undertaken only in an emergency or as a direct result of a public complaint; and
- All of the counties and most of the cities use tractor sidearm mowers, of either the rotary or flail type, that have a swath of five to six feet and do not allow for collection of clippings. The only exceptions found are the cities of Lacey, which contracts with a local lawn maintenance company that uses push-mowers and removes clippings, and Federal Way, which uses riding mowers on their wetponds and bioswales.

Mowing operations take up over 50 percent of the budgets for vegetation maintenance in stormwater facilities. Due to the vast differences in accounting and management procedures at the different agencies, an exact average cost per facility or cost per mile of roadside ditch is difficult to calculate. The most reliable and recurring figures range from $200-$300 per wetpond or bioswale per mowing, and an average in the same range for cost-per-mile of mowing the roadside ditches. The variations for wetponds and bioswales arise from the different sizes of facilities, the different types of activities performed, and the number of facilities that are maintained.

The figures for roadside ditch mowing are more difficult to calculate because of the differences in practices undertaken over the course of the year. Mowing the shoulders with a sidearm rotary mower can cost one-tenth as much as mowing the backslopes of the ditches. The reported figures may represent a full ditch mowing or just the mowing of the shoulder, which is the only practice undertaken during the heaviest growing season by some agencies. This is shown

in the data from Thurston County, for example: specific costs per mile are only $54 for shoulder mowing but $542 for back-slope mowing.

There are also differences in reporting total mileage. It is often unclear whether the numbers represent total road miles; total ditch miles (which may or may not equal 2 times the road miles); or total pass miles, which represent how far the tractor has to travel in the course of mowing regardless of how many passes it may take to mow one section of ditch.

Other problems were encountered in quantifying specific unit costs. For example, many of the agencies are in the process of summarizing data into Geographic Information Systems and computerized databases, so accurate information is not yet available. Some agencies do not break out mowing in their budgets as a separate account from either vegetation or overall road maintenance.

ANALYSIS

There is a significant lack of empirical information on the effects of different types of maintenance practices on the pollutant removal performance of bioswales, wetponds, and roadside ditches. Studies have been conducted on the effectiveness and efficiencies of the different design aspects of bioswales and wetponds, but conclusions on the most desirable types and characteristics of vegetation for optimizing pollutant removal performance have been made only through observation and professional judgment (Louise Kulzer and Zahid Khan, personal communication, 1997). These observations have been the only information available on this particular aspect of maintenance, and therefore they have been incorporated into the King County and Department of Ecology design manuals. Since these manuals are dictating the nature and magnitude of mowing practices, an activity that requires a significant fraction of overall agency maintenance budgets, it is apparent that some specific research should be conducted in this area. Horner (1988) identified this need in a report on biofiltration systems ten years ago, but it appears that no investigations have since occurred.

The survey shows that actual current practices in most Puget Sound lowland jurisdictions do not follow either Washington State guidance or the King County Design Manual. In general, current budgets do not allow for the specified type of intensive maintenance over the course of the growing season. Most of the agencies mow their facilities and ditches on a rotating cycle with tractor sidearm equipment that is either rotary or flail mowers. This equipment is required if all of the sites will be visited two to three times per growing season, but it does not allow for removal of clippings. Such removal would require, in most cases, hand-raking. Only one city (Lacey) is performing the maintenance as prescribed and they are achieving this through contracting with a lawn maintenance company at a relatively modest cost-per-visit (Table 2).

The consequences of these substandard maintenance practices on water quality, however, are unknown. Specific research on the need to remove the clippings from the swales and ponds could either justify or eliminate the requirement for this aspect of the maintenance and establish whether this practice would be of practical benefit in roadside ditches to increase their pollutant removal capabilities.

SUMMARY AND RECOMMENDATIONS

The long-standing attention to improving the water quality of storm runoff has traditionally focused on the types of facilities that can successfully remove pollutants. Significant effort has been invested in determining the optimal design of such facilities, their anticipated performance, and their net cost. Under the influence of this collective but largely uncritical emphasis on the *design* of structural controls, municipalities across the country now require such facilities as an ordinary part of new development. Many of the jurisdictions will take on long-term maintenance responsibilities for these facilities after construction, typically with little consideration of the cost or requirements represented by such an obligation.

Unfortunately, such an emphasis has failed to acknowledge some of the factors that are most important in determining the water quality of storm runoff, particularly at the urban fringe. These factors include (1) the level of maintenance of "formal" water-quality facilities, such as biofiltration swales and wet ponds, that must occur in perpetuity after these carefully designed structures are actually constructed; and (2) the improvement (or degradation) to water quality that is contributed by "informal" water-quality facilities, such as road ditches, that are in fact the single most common element of the constructed drainage system across vast tracts of all developing regions.

These issues of stormwater management have attracted little attention to date. They are mundane and as commonplace as the roads we drive down every day. Yet in many landscapes the net consequences of construction-related erosion, facility maintenance, and perhaps even the design and maintenance of road ditches can be the most important determinants of downstream water quality. The historic attention on facility *design* is laudable but inadequate; if our interest is in genuine improvement to water quality, we must attend to all elements of the stormwater system, including the long-term operation and maintenance of that system.

This report indicates the significant costs associated with the maintenance of roadside ditches, bioswales, and wetponds. On average, mowing operations of these facilities in particular consume over half of the vegetation management allocations of those budgets. With increasing restrictions in funding competing with the increasing awareness for the need to treat stormwater, justification for increasing or decreasing the intensity of current management practices is critical.

There are three principal areas where additional research is needed:

- **Grass Height and Density**

  Different maintenance practices produce different characteristics in the vegetation, but the optimal grass heights and densities for pollutant removal are unknown, as are the best methods to achieve and maintain those heights.

- **Pollutant Removal**

  Removal of clippings is believed to be important as a primary mechanism to remove pollutants from the system. However, this is a very costly (and almost universally ignored) requirement. It would be beneficial to establish whether these benefits really

occur and if there is a particular time of year that clipping removal is most effective. Little is known about the actual physical uptake of pollutants in stormwater facilities and where it occurs—along the swale or within the plants themselves. If these mechanisms can be established, the relevant properties can be emphasized in future facilities and maintenance measures can be designed to optimize pollutant removal. If they turn out to be unimportant, then design-manual standards can be changed to reflect this reality.

- **Costs and Benefits**

  Any recommendations in terms of alternative maintenance practices may require different types of equipment and scheduling or manpower. If different proposals are made they will need to be accompanied by specific figures on the additional (or reduced) costs, and specific benefits, before any changes in maintenance practices are likely to occur.

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Table 1: Contacts for Vegetation Maintenance Practices Survey

	CITY/ COUNTY/ OTHER	NAME	PHONE	TITLE/DEPT
COUNTIES	King County	John Cassidy	(206) 296-8148	Roads Supervisor
		Dave Hancock	(206) 296-8230	WLRD[1]
		Henry Kuga	(206) 896-8144	Roads Dept.
		John Koon	(206) 296-8062	WLRD
		Louise Kulzer	(206) 296-1980	WLRD
		Zahid Khan	(206) 296-1928	WLRD
	Kitsap County	Joe Zukauskus	(360) 876-7048	SWM[2]
	Pierce County	John Schnaderbeck	(253) 798-2953	Roads Forester
		Will Kinne	(253) 798-2953	Roads Supervisor
	Skagit County	Cliff Butler	(360) 755-9531	Roads Dept.
	Snohomish County	Bill Lief	(206) 388-3464	SWM
	Thurston Co.	Mark Swartout	(360) 754-4681	SWM
		Lane McAllister	(360) 786-7195	Roads Dept.
		Mark Cook	(360) 754-4681	SWM
	Whatcom Co.	Ken Hudson	(360) 676-6759	Veg. Maintenance Supervisor
CITIES	Auburn	Mike Martin	(253) 931-3048	Public Works
	Bellevue	Pete Blaine	(425) 452-7947	Roads Dept.
		Randy Holmes	(425) 453-4891	Roads Dept.
		Rick Watson	(425) 452-4896	SWM
	Edmonds	Bill Stroud	(206) 771-0235	Public Works
		Don Fiene	(206) 771-0220	SWM
	Everett	Jane Zimmerman	(206) 259-8800	SWM
	Federal Way	Jeff Pratt	(206) 661-4135	SWM
	Issaquah	Brett Heath	(206) 391-1044	Public Works Supervisor
		Loren Reinhelt	(253) 557-2517	SWM
	Kent	Bill Wolinski	(253) 859-6078	SWM
		Mike Pulliam	(253) 859-3395	Public Works
		Neldon Hewett	(253) 859-3343	Roads Dept.
	Lacey	Tim Reisher	(360) 438-2674	SWM
	Mountlake Terrace	Bob Henderson	(206) 776-1161	Public Works
	Olympia	Andy Hobbs	(360) 753-8481	SWM

		Mark Blosser	(360) 753-8320	SWM
		Mike Micheals	(360) 754-4681	Asst. Design Eng.
	Port of Seattle	Scott Tobiason	(206) 728-3171	SWM
	Puyallup	Tim Otto	(253) 841-5469	Public Works
	Redmond	Bill Tibbetts	(206) 556-2814	SWM
		Chuck Schwinn	(206) 556-2814	SWM
		John Armstrong	(205) 556-2821	Roads Dept.
	Seattle	Robert Chandler	(206) 684-7597	SWM
		Charlie Cox	(206) 684-7506	Roads Dept.
	Tacoma	Steve Stanley	(253) 502-2124	Public Works
		Tim Sparling	(253) 502-2128	SWM
STATE & NATIONAL	WA Dept. of Ecology	Debbie Helstrom	(360) 407-7158	
	WA Dept. of Transportation	Ed Molash	(360) 705-7507	
	WA Dept. of Ecology	Ed O'Brien	(360) 407-6438	
	State of Delaware	Earl Shaver	(302) 739-4411	
	Portland, OR	Eric Strecker	(503) 948-7253	Woodward-Clyde[3]
	Denver, CO	Ben Urbonas	(303) 455-6277	SWM
	Private consulting	Gary Minton	(206) 282-1681	Principal
	University of Washington	Rich Horner	(206) 782-7400	
	University of Central Florida	Marty Wanielista	(407) 823-2165	
	University of Virginia	Shaw Yu	(804) 924-6377	
	Center for Watershed Protection	Tom Schueler	(301) 589-1890	Director

[1]Water and Land Resources Division
[2]Surface or Storm Water Management
[3]Consulting Firm

Table 2: Current Vegetation Management Practices and Budgets in the Puget Sound Region

	AGENCY	MOWING BUDGET ($/YEAR)	MOWING FREQUENCY (TIMES/ YEAR)	NUMBER OF FACILITIES[1]	MILES OF DITCHES MOWED[2]	APPX COST PER FACILITY[3]	A C M
COUNTIES	**King Co. (Roads)**	~1,474,000	~ 2	n/a	4779 pass miles	n/a	$
	King Co. (WLRD)	459,472	2-3	527	n/a	$280	
	Pierce Co.	160,000	2-3	200+	3250	$200	
	Thurston Co.	~500,000	1-3	n/a	1700+	n/a	v
	Skagit Co.	294,000	2-3	n/a	1727	n/a	$
	Whatcom Co.	n/a	.4	n/a	~1500	n/a	
CITIES	**Auburn**	33,500	~5	35	27	~$175	~
	Bellevue (Roads)	60,000	varies	n/a	600	n/a	$

Bellevue (SWM)	23,200	1	260	n/a	~$550	
Edmonds	~10,000	3	1	~20	n/a	$
Everett	0	0	100-200	0	0	
Federal Way	60,000-70,000	3	60	n/a	330	
Issaquah	3,270	3	9	168	n/a	
Kent	58,600	varies	128	150	$65 - $521	$
Lacey	8,800	~10	12	~400	see comments	
Mountlake Terrace	n/a	see comments	1	n/a	n/a	

Olympia	0	0	n/a	n/a	n/a	
Redmond (Roads)	n/a[4]	4-5	n/a	n/a	n/a[4]	
Redmond (SWM)	58,000	~7-8	17	n/a	~$450	
Seattle (Roads)	36,000	1	n/a	50	n/a	~
Seattle (SWM)	~2,400	2	see comments	n/a	~$240	
Tacoma	0	0	n/a	n/a	n/a	

[1] Total number of bioswales and wetponds
[2] Miles mowed can be pass miles, total miles mowed per year, road miles mowed, or ditch miles mowe
[3] Cost is per visit
[4] Budgeted by hours ($ figures not available on roads)
(numbers preceded by " ~" are approximate)